CALIPSO Quality Statement: Wide Field Camera Level 1B Scans Data Release Version: 1.10

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Introduction

This document provides a high-level quality assessment of the CALIPSO Level 1B Wide Field Camera (WFC) data products, as described in Section 2.4 of the CALIPSO Data Products Catalog (Version 2.4) (PDF). As such, it represents the minimum information needed by scientists and researchers for appropriate and successful use of these data products. We strongly suggest that all authors, researchers, and reviewers of research papers review this document for the latest status before publishing any scientific papers using these data products.

The purpose of these data quality summaries is to inform users of the accuracy of CALIOP data products as determined by the CALIPSO Science Team and Wide Field Camera Science Working Group. This document is intended to briefly summarize key validation results; provide cautions in those areas where users might easily misinterpret the data; supply links to further information about the data products and the algorithms used to generate them; and offer information about planned algorithm revisions and data improvements.

Additional Documentation and References

Algorithm Theoretical Basis Documents (ATBDs)

- PC-SCI-205 - WFC Level 1 ATBD (PDF)

General References

- PC-SCI-503 : CALIPSO Data Products Catalog (Version 2.4) (PDF)
- Additional publications (journal articles and conference proceedings about CALIPSO science, algorithms, and data processing)
- CALIPSO Data Read Software

CALIPSO WFC Level 1B Data Product Description

The primary Wide Field Camera Level 1B data products are calibrated radiance and bidirectional reflectance registered to an Earth-based grid centered on the Lidar ground track. During the normal operation, the WFC acquires science data only during the daylight portions of the CALIPSO orbits. For each orbit, three different data files are produced: 1 km Native Science grid, 125 m Native Science grid, and 1 km Registered Science grid. The 1 km Native Science grid covers the full 61 km swath centered on the Lidar track. The 125 m Native Science grid contains only the central 5 km wide high resolution portion of the WFC swath. The 1 km Registered Science grid provides WFC data on the identical grid as the CALIPSO IIR data and is produced to facilitate the use of the WFC data in the IIR retrievals. In addition to radiance and reflectance grids, the WFC Level 1 data products include two parameters that quantify the homogeneity of the cross track image frames: swath homogeneity and track homogeneity. The major categories of WFC Level 1B data in each file type are:

- WFC 1 km x 1 km Native Science Data (full 61 km swath)
  - Radiance
  - Reflectance
  - Swath Homogeneity
  - Position Data
  - Viewing Geometry
- WFC 125 m x 125 m Native Science Data (central 5 km swath only)
  - Radiance
  - Reflectance
  - Track Homogeneity
  - Position Data
  - Viewing Geometry
- WFC 1 km x 1 km Registered Science Data (IIR grid)
  - Radiance
  - Reflectance

- Swath Homogeneity
- Position Data
- Viewing Geometry

For the convenience of the user, we describe the contents of each of the three major file types separately below. Note, in isolated cases satellite ephemeris and attitude data may be missing for a portion of an orbit. In these cases, the geolocation process will fail and fill values (-9999) will be reported in all position and viewing geometry fields. In addition, the Pixel QC Flag (see below) will also be set appropriately for no geolocation. However, due to a known software error, the Pixel QC Flag (see below) in this data release will not always be set appropriately for missing geolocation data.

WFC 1 km Native Science Data

(see Table 20 in CALIPSO Data Products Catalog (Version 2.4))

The 1 km Native Science data product provides WFC radiance and reflectance measurements across the full 61 km swath at 1 km resolution. The 125 m data in the central 5 km swath have been interpolated to 1 km resolution to fill in this portion of the swath. No additional spatial interpolation is performed.

Scan Time
This field reports the International Atomic Time (TAI) for each WFC scan, in seconds, starting from January 1, 1993.

Scan UTC Time
This field reports the Coordinated Universal Time (UTC) for each WFC scan with a format 'yymmdd.ffffffff', where 'yy' is the last two digits of year, 'mm' and 'dd' represent month and day, respectively, and 'ffffffff' is the fractional of the day.

Latitude
This field reports the latitude of the individual 1 km WFC pixel on the surface.

Longitude
This field reports the longitude of the individual 1 km WFC pixel on the surface.

Radiance
The band-average spectral radiance of the scene averaged over the spectral range of the WFC (620-670 nm). Units are $Wm^{-2}sr^{-1}\mu m^{-1}$.

Reflectance
The bi-directional reflectivity of the scene defined as the ratio of the intensity of the radiation reflected from the surface and atmosphere as observed by the WFC and the intensity of the incident solar radiation at the top of the atmosphere. It is has no units.

1 km Homogeneity
The 1 km or swath homogeneity is defined as the variance in radiance over the full 61 km cross-track swath normalized by the swath mean. The spatial resolution of the swath homogeneity is 61 km cross-track and 1 km along-track.

Solar Zenith Angle
The angle between the zenith at the WFC pixel footprint on the surface and the line of sight to the sun.

Solar Azimuth Angle
The azimuth angle measured from north to the line of sight to the sun.

Viewing Zenith Angle
The angle between the WFC viewing vector and the zenith at the WFC pixel footprint on the surface.

Viewing Azimuth Angle
The azimuth angle measured from north to the WFC viewing vector.

CCD Temperature
Temperature of the focal plane of the WFC CCD array. The temperature of the WFC detector is actively controlled by a TEC. The set point is 0^o C and the nominal range is about +/- 0.5^o. Larger excursions have been observed with no impact on the data quality. However, if excursions exceed more than about +/-5^o, the data should be used with caution.

Base Plate Temperature
Temperature of the feet of the WFC housing. Typically ranges between 10^o C and 20^o C. Primarily used as a diagnostic tool.

Reflectance Bins
Statistics on the observed WFC reflectance are produced for each orbit and reported here. The data are sorted into 5^o solar zenith angle bins (0-5^o, 5-10^o, 10-15^o, etc). There are 72 reflectance bins within each solar zenith bin and the total number of occurrences per orbit is reported in each bin.

Pixel QC Flag
This is a 32-bit integer to identify potential data quality issues. Only the first 5 bits are used as described below. Most data will have

QC Flag values of zero; however, such as in the case of missing satellite ephemeris and attitude data, this will not always be true. If the QC Flag value is greater than 1, the data should be used with caution. If the QC Flag value is greater than 3, the data should not be used. Note, due to a known software error, bit 3 may not always be set properly in this data release. However, pixels with no geolocation will be identified with fill values in the position fields.

Bit Definition:

1. Center pixel not defined in level 0 data
2. Radiance exceeds max count...saturated pixel
3. Cannot geolocate
4. Negative radiance
5. Negative reflectance

WFC 125 m Native Science Data

(see Table 21 in CALIPSO Data Products Catalog (Version 2.4))

The 125 m Native Science data product provides WFC radiance and reflectance measurements across just the central 5 km swath at 125 m resolution. No spatial interpolation is performed.

Scan Time
This field reports the International Atomic Time (TAI) for each WFC scan, in seconds, starting from January 1, 1993.

Scan UTC Time
This field reports the Coordinated Universal Time (UTC) for each WFC scan with a format 'yymmdd.ffffffff', where 'yy' is the last two digits of year, 'mm' and 'dd' represent month and day, respectively, and 'ffffffff' is the fractional of the day.

Latitude
This field reports the latitude of the individual 125 m WFC pixel on the surface.

Longitude
This field reports the longitude of the individual 125 m WFC pixel on the surface.

Radiance
The band-average spectral radiance of the scene averaged over the spectral range of the WFC (620-670 nm). Units are $Wm^{-2}sr^{-1}\mu m^{-1}$.

Reflectance
The bi-directional reflectivity of the scene defined as the ratio of the intensity of the radiation reflected from the surface and atmosphere as observed by the WFC and the intensity of the incident solar radiation at the top of the atmosphere. It is has no units.

125 m Homogeneity
The 125 m or track homogeneity is simply as the standard deviation in radiance over the central 5 km high-resolution portion of the WFC image frame normalized by the mean.

Reflectance Bins 125 m
Statistics on the observed WFC reflectance are produced for each orbit and reported here. The data are sorted into 5^o solar zenith angle bins ($0\text{-}5^o$, $5\text{-}10^o$, $10\text{-}15^o$, etc). There are 72 reflectance bins within each solar zenith bin and the total number of occurrences per orbit is reported in each bin.

Pixel QC Flag
This is a 32-bit integer to identify potential data quality issues. Only the first 5 bits are used as described below. Most data will have QC Flag values of zero; however, such as in the case of missing satellite ephemeris and attitude data, this will not always be true. If the QC Flag value is greater than 1, the data should be used with caution. If the QC Flag value is greater than 3, the data should not be used. Note, due to a known software error, bit 3 may not always be set properly in this data release. However, pixels with no geolocation will be identified with fill values in the position fields.

Bit Definition:

1. Center pixel not defined in level 0 data
2. Radiance exceeds max count...saturated pixel
3. Cannot geolocate
4. Negative radiance
5. Negative reflectance

WFC 1 km Registered Science Data

(see Table 18 in CALIPSO Data Products Catalog (Version 2.4) (PDF))

To facilitate the use of the WFC data in IIR retrievals, the WFC radiometric data is also registered to the same Earth-based geometric grid as the IIR data. This grid projection has been defined as follows:

- Grid lines are orthogonal to the lidar track
- Center point in each grid line is aligned with the lidar track
- Center point is registered with a lidar shot
- Grid lines are separated by about 1 km, but exact sampling is determined by translation of sub-satellite point during a time Δt equivalent to 3 lidar shots (i.e. ~148 ms)

The WFC data are registered to the IIR grid by interpolation of the "native grid" data using a bilinear interpolation scheme.

Lidar Shot Time
This field reports the International Atomic Time (TAI) for each Lidar shot that defines a grid line, in seconds, starting from January 1, 1993.

Lidar Shot UTC Time
This field reports the Coordinated Universal Time (UTC) for each Lidar shot that defines a grid line, with a format 'yymmdd.ffffffff', where 'yy' is the last two digits of year, 'mm' and 'dd' represent month and day, respectively, and 'ffffffff' is the fractional of the day.

Latitude
This field reports the latitude of the individual 1 km WFC grid points on the surface.

Longitude
This field reports the longitude of the individual 1 km WFC grid points on the surface.

Radiance
The band-average spectral radiance of the scene averaged over the spectral range of the WFC (620-670 nm). Units are $Wm^{-2}sr^{-1}\mu m^{-1}$.

Reflectance
The bi-directional reflectivity of the scene defined as the ratio of the intensity of the radiation reflected from the surface and atmosphere as observed by the WFC and the intensity of the incident solar radiation at the top of the atmosphere. It is has no units.

1 km Homogeneity
The 1 km or swath homogeneity is defined as the variance in radiance over the full 61 km cross-track swath normalized by the swath mean. The spatial resolution of the swath homogeneity is 61 km cross-track and 1 km along-track.

Solar Zenith Angle
The angle between the zenith at the WFC grid point on the surface and the line of sight to the sun.

Solar Azimuth Angle
The azimuth angle measured from north to the line of sight to the sun.

Viewing Zenith Angle
The angle between the WFC viewing vector and the zenith at the WFC pixel footprint on the surface.

Viewing Azimuth Angle
The azimuth angle measured from north to the WFC viewing vector.

Pixel QC Flag
This is a 32-bit integer to identify potential data quality issues. Only the first 5 bits are used as described below. Most data will have QC Flag values of zero; however, such as in the case of missing satellite ephemeris and attitude data, this will not always be true. If the QC Flag value is greater than 1, the data should be used with caution. If the QC Flag value is greater than 3, the data should not be used. Note, due to a known software error, bit 3 may not always be set properly in this data release. However, pixels with no geolocation will be identified with fill values in the position fields.

Bit Definition:

1. Center pixel not defined in level 0 data
2. Radiance exceeds max count...saturated pixel
3. Cannot geolocate
4. Negative radiance
5. Negative reflectance

Data Release Versions

Wide Field Camera (WFC) Level 1B Scans Information Half orbit (Day) geolocated data radiances			
Release Date	**Version**	**Data Date Range**	**Maturity Level**
December 8, 2006	1.10	June 13, 2006 to September 21, 2010	Provisional

Data Quality Statement for the release of the CALIPSO Product WFC Level 1B Scans Version 1.10, December 8, 2006

The WFC is currently fully functional and operating nominally. To date, the WFC data quality assessments have been focused on two primary areas: geolocation and radiometric accuracy. Post-launch checks of the WFC geolocation identified both along-track and cross-track biases in the reported WFC pixel locations. These systematic offsets were on the order of several 100 meters and were attributed to a small, uncharacterized misalignment of the WFC relative to the spacecraft platform. Geolocation corrections have been implemented in the Level 1 ground processing to eliminate these biases. WFC geolocation accuracy for the V1.10 data release is estimated to be better than 50 m. There is no on-orbit radiometric calibration capability for the WFC. Therefore, we must rely on vicarious approaches to verify and monitor the WFC radiometric calibration. Since the WFC bandpass is matched to the well-calibrated Aqua MODIS Channel 1, direct comparisons with nearly coincident MODIS Channel 1 measurements provide an excellent means of assessing the WFC radiometric performance. Preliminary comparisons of WFC and Aqua MODIS channel radiance measurements indicated that the WFC radiometric measurements were biased high relative to MODIS by about 10%. Further investigation revealed that an offset in the reported WFC exposure time was the likely cause of this bias. A review of pre-launch ground test data and results from diagnostic experiments performed on-orbit confirmed that the true WFC exposure time is about 0.4 ms longer than reported. Accounting for this exposure time offset results in about a 9% reduction in the magnitude of the WFC radiance values. This correction has been implemented in the Level 1 processing for the V1.10 data release. A more detailed assessment of the WFC on-orbit performance has been performed based on analysis of WFC and MODIS data from the first twelve months of the CALIPSO mission. Using deep convective clouds as vicarious calibration targets, direct comparisons of WFC and MODIS radiance measurements indicate that the WFC radiance tracks the MODIS data very closely with daily mean differences never exceeding 1.2%. Analysis of WFC and MODIS deep convective cloud reflectance distributions also indicate that the WFC has exhibited excellent radiometric stability during the first year of operation with no apparent drift relative to MODIS. For more details, please see Pitts et al. (2007) (PDF).